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this day ; for my father knows already that you have entered here, and I see him running speedily with a naked sword to kill you." Nathan threw himself at her feet, kissed them, and bathed in tears, entreated her to pity him : save me, said he, beautiful queen, save me from this imminent danger, and from the wrath of your father : I protest to you I did not enter here with any bad design, and that I had not the least intention to behave with disrespect, to the beautiful girls, who have the honour to wait on you. The daughter of Asmodeus, who was called Mitra, looked on him with pity and said to him, your modesty charms me, and because you are so learned in the divine law, I wish to preserve you from the great dangers which threaten you. Depart then instantly from the palace, and when my father shall come, and shall overwhelm you with his accusations, and shall say why have you disobeyed my commands ? and why have you entered into the palace of my daughter ; and shall desire to kill ; answer him ; my lord, I entered into the palace from no other motive, but because I love your daughter so ardently that I cannot live without her, and that I can have no greater pleasure than to receive her in marriage. I am sure, added she, that these words will be very pleasing to him, and that he will wed me to you, for from the time that you have arrived in our land, he has frequently thought of making you his son-in-law, not being able to recompense more highly the excellence which you have acquired in the interpretation of the holy scriptures : and you know it is not proper that a girl of my rank should make love to a man, or that so great a king as my father should solicit you to take his daughter in marriage.

To be Continued.

Extract of a letter from Richard Lovell Edgeworth, esq. to a Member of the Committee for the improvement of Roads, &c. dated Edgeworth Town, 14th March, 1808.

I WITH pleasure communicate to you some hints on the subject

of wheel-carriages, which I had proposed to examine in detail, and to publish, with some new inventions ; in the mean time, if they can be of any use to you, they are much at your service.

The problem to be solved is this.— Giving a certain road, how to construct a carriage so, that, every thing taken into consideration, it may be fit to carry the goods, required to be carried on that road, with the most convenience, and at the least expense.

The legislature will in all probability turn its attention chiefly to the means of preserving the roads, and this is undoubtedly an object of the utmost national importance ; but then it is not to be considered as the only object, because the original price and the annual repairs of the road, fall ultimately, or ought to fall upon the persons who use the road : therefore, the original cost and the repairs of the public roads become part of the price of carriage to the consumer. If a number of manufacturers were to make a road for their own use and at their own expense, they would be led to consider, what kind of carriages would be the most suitable for the commodities they had to carry, what could be drawn by the fewest horses, what would cost least originally, and would become least subject to wear and tear ; and lastly, what carriages would do the least injury to the road which they were to make, and keep in repair. The whole of these considerations may be resolved into this single question ; what road and carriage will ultimately be the least expensive.

If a constant hourly traffic was to be carried on, our company would find iron railways by far cheaper than any other kind of road. Next to iron railways, pavement composed of large flat stones jointed with care, as in some parts of London, would be the best ; but such stones, sufficiently hard, and sufficiently near the spot, cannot always be had. To supply their place, the hardest stone that can be procured should be broken into irregular fragments of various sizes, and laid upon the

road. The road should be first laid out in a regular and gentle curve, and be beaten or rolled, so as to be *equally* firm in all its parts. The goodness of the road depends more upon this circumstance than is usually imagined; for let the road be ever so hard and smooth at the surface, wherever the foundation is unsound, the superstructure will give way. After the road has been *laid* eight or ten inches deep with stone, it should be slightly covered with mixed gravel, the various sizes of which will fill up the interstices of the stones, and at once permit horses and carriages to travel conveniently; but daily attention should be paid to the road to fill every crevice with small stones, and to break every prominent stone into small pieces, over which amended spots some gravel should be sprinkled to cement the parts. In a short time the gravel will disappear, and the tops of the stones, the angles of which have been ground off, should be carefully broken with light hammers; the edges of the track made by carriages should in the same manner be broken down, and no pains should be spared to make the whole surface of the road equally hard and equally smooth. This appears to be a tedious process, but it will amply repay the time and labour bestowed upon it. Wherever there is a hill of any considerable acclivity, the road should be made much higher in the middle than on flat ground, to prevent water from running across the road, which in many places cuts the surface chequer-ways, as may be seen in Derbyshire and Wales, where the roads are hard.

If carriages, that are not too heavy for the strength of the materials, and wheels not so narrow as to cut the surface are used, and if these wheels are of a proper size and strength, and are skillfully applied to a convenient carriage, our partnership will have the cheapest mode of transporting their goods that can be obtained on land without the intervention of railways. Where hard materials cannot be found, the weight of the carriage must be diminished, and the wheels must be broader. What that weight and breadth should

be, may be determined by a knowledge of the relative strength of the materials, and this must be previously acquired by experiment. If in these roads, the gravel or stones are soon ground into powder, or squeezed into paste, the carriages commonly in use are too heavy for the materials of the road, and nothing but lightening the loads can remedy the evil. Where waggons and carts of different sizes travel, it may soon be discovered by examining their tracks, what weight the materials of the road are able to bear, and no weight beyond this should be permitted upon wheels of any breadth.

I have hitherto entered into no discussion of the mechanical advantages of wheels of different heights, forms, and breadths. I have seen a paper by my very ingenious and worthy friend Mr. Cumming, which was laid before the board of agriculture; this paper contained observations and deductions from experiment and theory, that determine many problems in the doctrine of wheel carriages. But the original source, from whence the most of what has been published in England is drawn, is a tract upon wheel carriages, entitled, "*Traité des Forces, Mouyantes, Par M. Camus, in 1722,*" and which is also inserted in the memoirs of the French academy. Part of this work is translated in Desaguliers. The principal points discussed are, the size of wheels, their breadth, their dishing, and their splay; that is to say, the obliquity of the spokes, and the deviation of the plane of the wheel from a perpendicular situation.

The rims of the wheels of a coach or waggon stand several inches farther asunder at the top than at bottom; the arms of their axle-trees bend downwards, so that if they were produced, they would touch the ground at no very great distance from the carriage. It is clear, that if one of these arms were cut off from the carriage with the wheel upon it, this wheel put in motion would not go straight forward, but would tend to describe a circle round the point where the arm touched the ground, and would continue to move round this point as long as it was kept in motion, without counteracting

its tendency to describe a circle. If the wheel on the other arm of the axle-tree were detached in the same manner, it would describe a similar circle (which would be the evolution of a cone) but in a direction contrary to that in which the other wheel would move, one wheel moving from right to left, and the other from left to right. Now a great force is requisite to oblige these wheels to go in straight lines; for while the wheel moves forward through space equal to the circumference of the circle which it would describe if at liberty, the sole of the wheel must slide on the ground by a twisting motion, through a space equal to the diameter of that circle.*

It is easy to calculate what this resistance would amount to; but I am only writing hints, not a treatise. Hitherto the best mode of carriage for a society of manufacturers has been considered, who could leave what distance they thought best between the wheels of their carriages. Let us now apply this to the public in general, who like a private company must ultimately pay the whole expense of the road, its repairs, and the cost of carriages, and horses, with their wear and tear. Now, the breadth of the track which wheels must keep is unlimited on a *private road*, and therefore the distance of their wheels may be such as to suit the convenience of the load without splaying the wheels; but the breadth of the track of wheels on *public roads* is limited by law, so that to gain room for stowage, the tops of the wheels of a waggon must splay outwards.

Acts of parliament require that the wheels of stage waggons should be nine inches broad, and even give premiums for the use of broader wheels; and also for placing wheels so as to roll in different contiguous tracks; by which means parallel paths are made for the horses. This has the appearance of good sense; but I believe it is not well founded; and the various evasions which carriers

practise to avoid the law, is a strong presumptive evidence that it is injurious. From what has been said of a private road, it appears that the breadth of waggon wheels should be regulated by the mean of two considerations: the ease of the draft, and the preservation of the roads. If the carriage of ten thousand ton of goods upon the broadest wheels prescribed by parliament, wear out the road so as to require only one hundred pounds per annum to repair it; and if wheels of any other breadth wear the same road so as to require a thousand pounds to repair it in the same time; one thousand one hundred pounds at least should be saved to the public by the reduced price of carriage, which the cheapness and lightness of the narrow-wheeled waggons could afford, or else the public must lose. Besides this, the better condition of the roads for other carriages is an object of great importance; and where the roads are soon broken up by any sort of carriage, that carriage should be prohibited. It is plain, therefore, that the same breadth of wheels cannot be suited to all sorts of materials, and that where these are the hardest, the wheels may be narrower than where the materials of the road are softer. And that where a stage waggon goes through counties of different soils, and where different materials abound in different places, the wheels and weight to be carried must be adapted to the medium strength of the materials; but should in no case be such as to crumble them to pieces. It cannot be doubted, that where the roads are sufficiently hard to bear the pressure of narrow wheels, without being cut by them, they are more advantageous to the carriage, not only because they are cheaper, but because all the breadth of the wheel beyond what is necessary to prevent them from immediately injuring the road, is an incumbrance and weight which must be carried continually, not only upon level roads, but up-hill, without being of any use, instead of profitable loading. The inconvenience therefore of very broad wheels must, in many cases, be considered as a contribution paid

* Equal to the difference of the two circles described by the inner and outer edges of the rim.

by the carrier to preserve the roads, by rolling them and levelling the incipient ruts made by other carriages.

The legislature, in lowering the tolls of widely-rolling waggons, recognizes this theory; and they are permitted to pass toll free upon certain roads, and at certain times; they would undoubtedly be highly advantageous, as it would prepare the road for lighter carriages, would efface from time to time the impressions which they made, and would consolidate all the materials which might be disturbed by frost or heavy rain.

I shall not detain you with the theory of high and low wheels, as it is laid down in every treatise on mechanics. The higher the wheels the better, provided their centers do not stand further from the ground than the point of the shoulder of the horse; from this it may be deduced, that tall horses for drawing heavy loads are preferable to low ones of the same strength. For pleasure or expedition, smaller and more active horses are preferable, because it is their speed, and not their strength, that is exerted.

Five feet six inches is a proper height for narrow wheels on a good road, but broad wheels should not be above four feet six high, as they lose more by additional weight than they gain by additional height.

As to the *form* of a wheel, it should be dished, that is to say, the spokes should be placed obliquely in the nave, for the purpose of resisting the lateral pressure of the load, which, in sloping or rough roads, would otherwise force the nave sideways through the rim of the wheel.

Where wheels are placed nearly perpendicular, instead of *dishing*, the spokes have been placed sloping alternately towards and from the shoulder of the axle tree. This practice has been followed, and laid aside at different periods, from caprice; but there is reason to suppose, that where wheels stand nearly upright, it is the best construction. For coaches, &c. there is an obvious objection to wheels of this form,

the naves cannot be made of so light and agreeable a form as in the common method.

Before I quit this subject, I shall mention one circumstance that has not, to my knowledge, been noticed by any author, relative to the splaying of wheels that are dished; the arm of the axle tree is so bent that when such wheels stand upon level ground, the spokes stand perpendicularly, and consequently are in the strongest situation to bear the superincumbent weight; this is commonly known. But besides this, as the spokes are driven into the nave as near as possible to the shoulder of the axle-tree, as may be easily conceived, by supposing that the spokes were driven into the wheel obliquely at the other end of the nave, for then the pressure would be entirely on the outward extremity of the axle-tree, and would act with a long lever against the axle-tree near its shoulder, a force that would soon break it, if it were not made much larger than it is at present.

The quantity of dirt taken up by wheels of different heights, breadths, and forms, should be attended to; it is in some places such as to increase the draft considerably.

The last of the three objects which I proposed to consider, is, the breadth of the wheels. As this relates as much to the kind of road upon which the wheels is to travel, it has already been considered in the beginning of my letter; but still the properties of a broad wheel rolling on a hard flat road should be noticed, as they may be applied to every modification of roads and wheels that occur in practice.

If a wheel of one-inch breadth were used in a common stage waggon, it would, even with a moderate weight, soon cut a deep rut in the road. If a wheel of two feet broad were used, it would press the parts of the road together, and would *not*, with the same weight, soon break or grind the materials, provided it were cylindrical, and placed upright on the road.

But as broad wheels never are so placed, they are pernicious and destructive when they exceed such

a breadth as will prevent them from making a visible hollow in the road the first time they roll upon it. I have reason to think that this breadth is about six inches, and that if the hind and fore wheels roll different tracks, other carriages might conveniently travel in their path.

Still the convenience of splaying the wheels will remain to tempt the waggoner, unless the breadth of the body of the waggon is contracted, the breadth of the track be extended, or the wheels lowered and placed under the body.

This last construction has considerable advantages, and was some years ago attempted by an ingenious mechanic, who published a book on the subject. These waggons were afterwards made and sold at the extensive and useful manufactory of Mr. Sharpe, 133, Tooley-street, where I have seen and examined them. They did not succeed, because they were to be used on roads that were cut into ruts and tracks which continually impeded their progress; but I have little doubt of the utility of carriages of this construction, provided the wheels or rollers were made lighter, by adopting the common form of spoked wheels shod with iron (perhaps cast iron) rims six inches broad, rolling in different tracks, and three feet six inches in diameter.

Such a construction would be nearly one ton lighter than a common broadwheeled waggon, and would therefore be one-fifth more advantageous, because it would carry one-fifth more goods, without requiring any additional force to draw it; for in all cases the draft is the same, whether the weight of the waggon consists of the load, and of the parts of the waggon itself, of which the weight of the wheels is sometimes thirty-two or even thirty-five hundred. It is true that the weight of the wheels adds nothing to the friction of the axle-tree. But this is scarcely worth attention.

Where cylindrical wheels placed nearly upright are employed, the arms of the axle-tree where the boxes run, at the outside extremity of the arm, should be made not more than

half the diameter of the same arm at the shoulder, so that the shape of the arm would be cylindrical at the shoulder, cylindrical at the end next the linch-pin, and conical between these two cylinders. I believe this to be the best form of an axle-tree, and it is not necessary to turn it in a lathe; if hung between the points in a lathe, and set truly by the hammer and slightly filed, the friction of the boxes will soon polish the parts that touch.

There is still another construction of carriages preferable to any that I have yet mentioned. I proposed it forty years ago to the society for the encouragement of arts, &c. It has lately been adopted in several places, particularly at the slate quarries near Bangor; it consists in dividing the weight to be carried into two or more parts, and placing them on separate carriages attached to each other. Thus, one driver only is required, whereas, if the horses drew each carriage separately, one driver could not manage them on crowded roads or in cities.

I published, I believe in 1803, in Nicholson's journal, a paper upon iron railways for all sorts of carriages. I shall resume the subject at leisure, believing, as I do most firmly, that the art of printing will preserve and promote whatever inventions are really useful, and discard whatever is trifling and impracticable; I never hurry forward a proposal of this sort, but leave the public time to form, gradually, a proper judgment.

If I am wrong, my errors will be rectified; if I am right, my plans will be adopted.

One more consideration occurs to me, which is in fact much more applicable to carriages that move with velocity, than to the slow-paced waggon; I mean the effect of *springs*, and the bending of the materials of which a carriage is made. In the transactions of the R. Irish academy, vol. 2,—1788, I published twenty years ago an essay on this subject, wherein I have demonstrated the utility of springs as they regard the ease of draft; in some cases lessening the resistance to the horses in a higher proportion than *ten to one*.

Now, although springs, such as those applied to coaches, cannot be usefully employed for heavy waggons, yet the timber of a waggon may be so adjusted as to yield to sudden shocks on rough roads or pavement.

Whoever observes the hinder part of a loaded waggon in motion, will perceive that the part of the body which projects beyond the hinder axle-tree, has a vibrating motion that eases the draft, and preserves what is carried in that part of the waggon from being so much shaken as what is placed over the axle-trees, or over the more unbending parts of the machine.

Indeed, whoever considers the subject even in a popular manner, must perceive, that the springs ease the horses as well as the rider; for, whatever jolting motion the latter receives, is communicated by the rising or falling of the carriage going over obstacles; the force of the horses alone produces this motion, and whatever lessens it lightens the horse's labour.

If sixteen people outside and inside of a stage coach are jolted upward even one-third of an inch in travelling one yard, it will require a constant force of twenty pounds to communicate so much motion to the carriage. The whole friction of the axle-trees does not obstruct the motion of the carriage much more than this slight vibration.

Now the springs commonly used diminish the resistance occasioned by such jolts above half, so that they are as advantageous as any contrivance that would lessen the friction of the boxes upon the axle-tree in proportion of two to one.

For the Belfast Monthly Magazine.

Third Report of the Committee appointed to take into consideration the Acts now in force regarding the use of Broad Wheels, &c.

(Continued from p. 193, No. XX.)

REGULATIONS REGARDING TURNPIKE TRUSTS.

1. *Resolved*, **T**HAT it is the opinion of this committee, that there be held in each

turnpike trust one general annual meeting of the trustees at the most convenient place, as near the centre of the said turnpike respectively as may be, in the months of September or October, for the purpose of examining and settling the accounts of the treasurers, clerks, surveyors and collectors, the appointments of new surveyors, and the necessary officers where vacancies have occurred, making contracts for letting tolls, repairing the roads, &c.

2. *Resolved*, That it is the opinion of this committee, that at the first meetings under the proposed act, two trustees be appointed in each trust by the majority then present, to examine the accounts and vouchers of the respective trusts, preparatory to their being laid before the trustees at the next annual meeting. That two trustees be constantly named for the like purpose at every subsequent annual meeting. That all officers be compelled to exhibit their accounts to the trustees so named, whenever called upon for examination. That no account be passed which shall not have been previously audited and signed by the trustees so appointed.

3. *Resolved*, That it is the opinion of this committee, that notice of such general annual meetings be given in the county paper, or in the paper in the most general circulation in the county, or in the gazette, for the neighbourhood of London, for three successive weeks before the holding of such meetings.

4. *Resolved*, That it is the opinion of this committee, that the trustees of every turnpike road shall be bound to exercise their trust impartially over the whole extent of road committed to their care, to keep so far as is practicable every part in an equal state of repair, and to apportion their net income according to an equal or an equitable distribution to every parish or district within their trust, according to the number of miles of turnpike within each district or parish. In cases where special reasons exist for allotting a greater proportion of their funds to any particular portion of road, or to any particular object of improvement, such reasons to be fully and distinctly entered in